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A regional and local geophysical study of the western overthrust belt in North-Western Huanuco, North Peru

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Abstract. The complicated tectonic history of Northern Huanuco poses great difficulties for geophysical studies in the area. A terrain-corrected, regional Bouguer gravity map of the area has been produced which reflects this complexity. This map is dominated by a northwest grade, which is apparently the result of a Paleozoic tectonic boundary. This boundary seems to have at least locally exerted control on younger features leading to considerable superposition of structures in the area. The Andean chain straddles the western coast of the South American continent, parallel to a subduction zone where the Nazca plate descends beneath the South American continental plate. The area of our research was located in the northern part of the Huanuco province. Four sites were surveyed. The gravity values were calculated dataset and Bouguer corrections were applied. Finally, a Bouguer anomaly map of Peru and Bouguer anomaly maps of sites was produced based on these data.

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Региональные и локальные геофизические исследования западного пояса надвигов на северо-западе Хуануко, Северное Перу

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Аннотация. Сложная тектоническая история северной части провинции Хуануко создает большие трудности для геофизических исследований в этом районе. Составлена региональная карта гравитации Буге с поправкой на рельеф местности, которая отражает данную сложность.

Ключевые слова:
гравиразведочные данные, магниторазведочные данные, локальные аномалии

На карте преобладают северо-западные ориентировки, которые, судя по всему, являются результатом влияния палеозойской тектонической границы. Выдвигается версия, что эта граница, по крайней мере локально, контролировала позицию более молодых объектов и тем самым повлияла на значительное усложнение структур в этом районе. Андская горная цепь тянется вдоль западного побережья Южноамериканского континента параллельно зоне субдукции, где океаническая плита Наска погружается под южноамериканскую континентальную плиту. Район проведения исследований располагался в северной части провинции Хуануко. Были обследованы четыре участка. Значения гравитационного поля рассчитаны по набору данных с применением поправки Буге. На основе этих данных составлена карта аномалий Буге территории Перу и карты аномалий Буге на участках исследований.

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Introduction

Any study of the western overthrust belt in the Northern Huanuco, and Northern Lliata is hindered by the complex tectonic history of this region. At least locally, events prior to the formation of the overthrust belt have imparted structural features to the area which probably influenced the formation of this belt. Younger events (Basin and Range – Rio Maranion rift deformation) have left most of the region buried by alluvium, and block faulting associated with these events both follows and transects the overthrust belt [1–3]. In addition to the overthrust belt, Paleozoic and Mesozoic intrusive and sedimentary rocks in the area are also important in terms of gold and cooper potential [1; 3; 4]. The Andean chain straddles the western coast of the South American continent, parallel to a subduction zone where the Nazca plate descends beneath the South American continental plate. The area of our research was located in the northern part of the province of Huanuco. Four sites were surveyed [5].

The purpose of the study is to clarify the geological reasons for the zoning of mineral deposits on the territory of Peru and Northern Huanuco.

1. Geologic and tectonic overview

Exposures of Paleozoic rocks in the study area (Figure 1) are somewhat limited. A. Pfiffer reports no significant Paleozoic outcrops in Southeastern Llata west of Huanuco [3]. In far Southwestern Huanuco, Precambrian outcrops consist mainly of granite with locally abundant metamorphic rocks [3]. The exposures are more significant towards the east. In the Cordillera Huayhuash Mountains the well exposed Precambrian Thunderbird Formation and its relation to the Precambrian Red Bluff Granite has been described in detail [1]. Although radiometric ages are available for outcrops in the Cordillera Huayhuash Mountains and farther east, the paucity of age data in far Southwestern Huanuco from either outcrop or deep exploration wells makes a regional interpretation of Precambrian events very tentative [3].

The Andean chain straddles the western coast of the South American continent, parallel to a subduction zone where the Nazca plate descends beneath the South American continental plate. During the Paleozoic, the area was dominated by the formation of the Maranion and Ualiago basins. A. Pfiffner and L. Gonzalez [3; 6] discuss in detail the development of these basins by correlating their stratigraphic and depositional similarities with the Permian Basin of West Huanuco and Southeastern Ankash (Figure 2). The Paleozoic strata in the study area are usually of shallow marine origin and thin generally towards the north [3].

While there are no Triassic rocks in the Maranion and Ualiago basins area [1; 3], the Middle Mesozoic was a time of major sedimentation in the Chihuahua trough [1]. The northwest marine transgression which followed during the Early Cretaceous [1; 7] resulted in a northward thinning Lower Cretaceous section. Triassic and Jurassic plutonism and volcanism in Southeastern Subandian zone are described [1; 4]. However [1] report that igneous activity of this age has not been recognized in Southwestern Huanuco.

Late Cretaceous-Early Tertiary deformation in the Eastern Cordillera Mountains of Huanuco was described by Hermoza et al. [1]. Drewes presents evidence that the Cordilleran orogenic belt of South America is continuous from Southern Huanuco beyond El Paso and his analysis implies that extensive compressional features are buried in the subsurface of the study area [1]. The notion that the trend of the Huanuco uplift continues in the subsurface is verified by an exploration well drilled to basement on the Ucayaly (Figure 3) basin Uplift in Northeastern Huanuco [8].

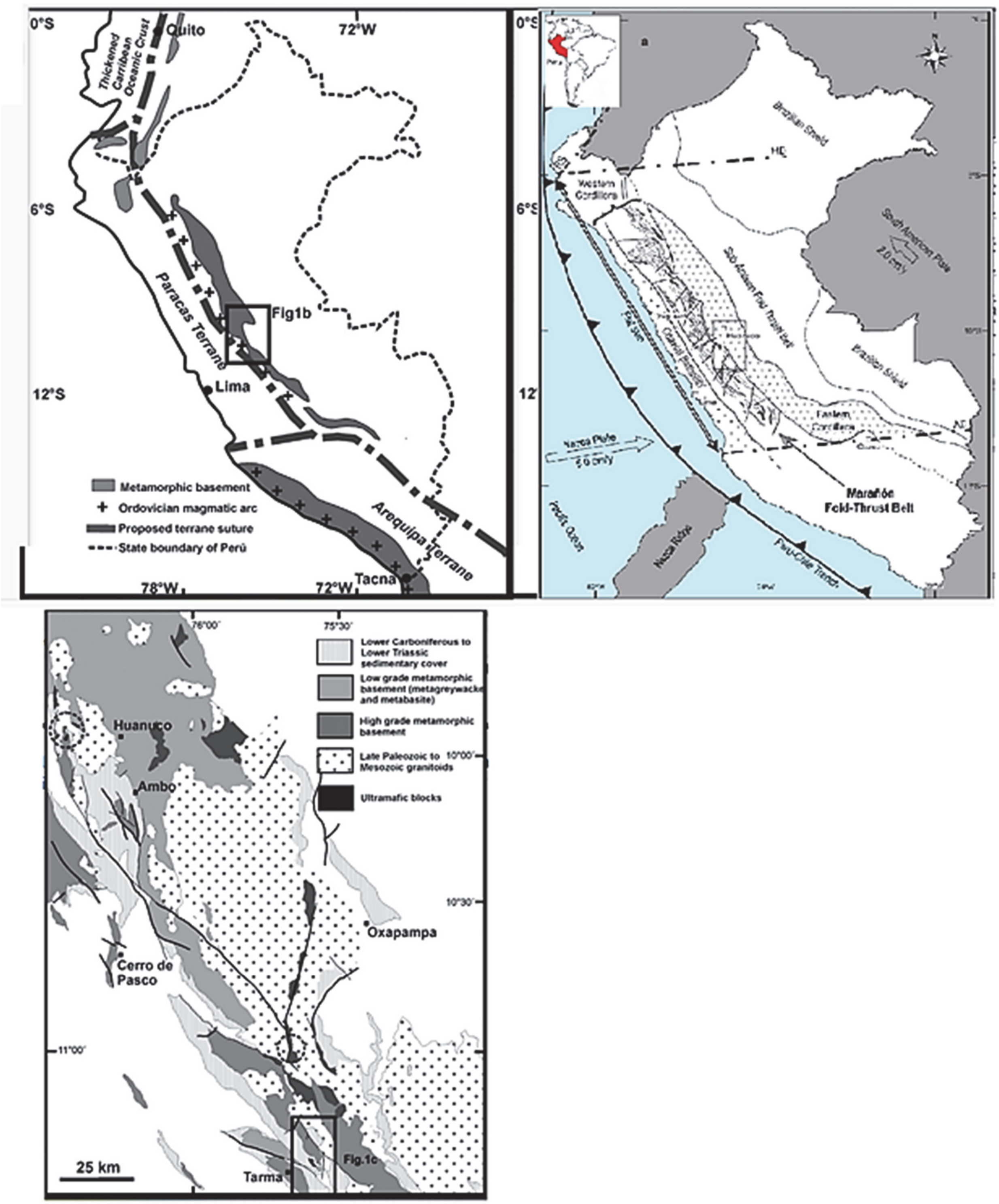

Figure 1. Overview geological maps of the study area (the upper left is the exits of the foundation and magmatic arcs, the upper right is the fault systems, the lower left is the map of location the work sites)

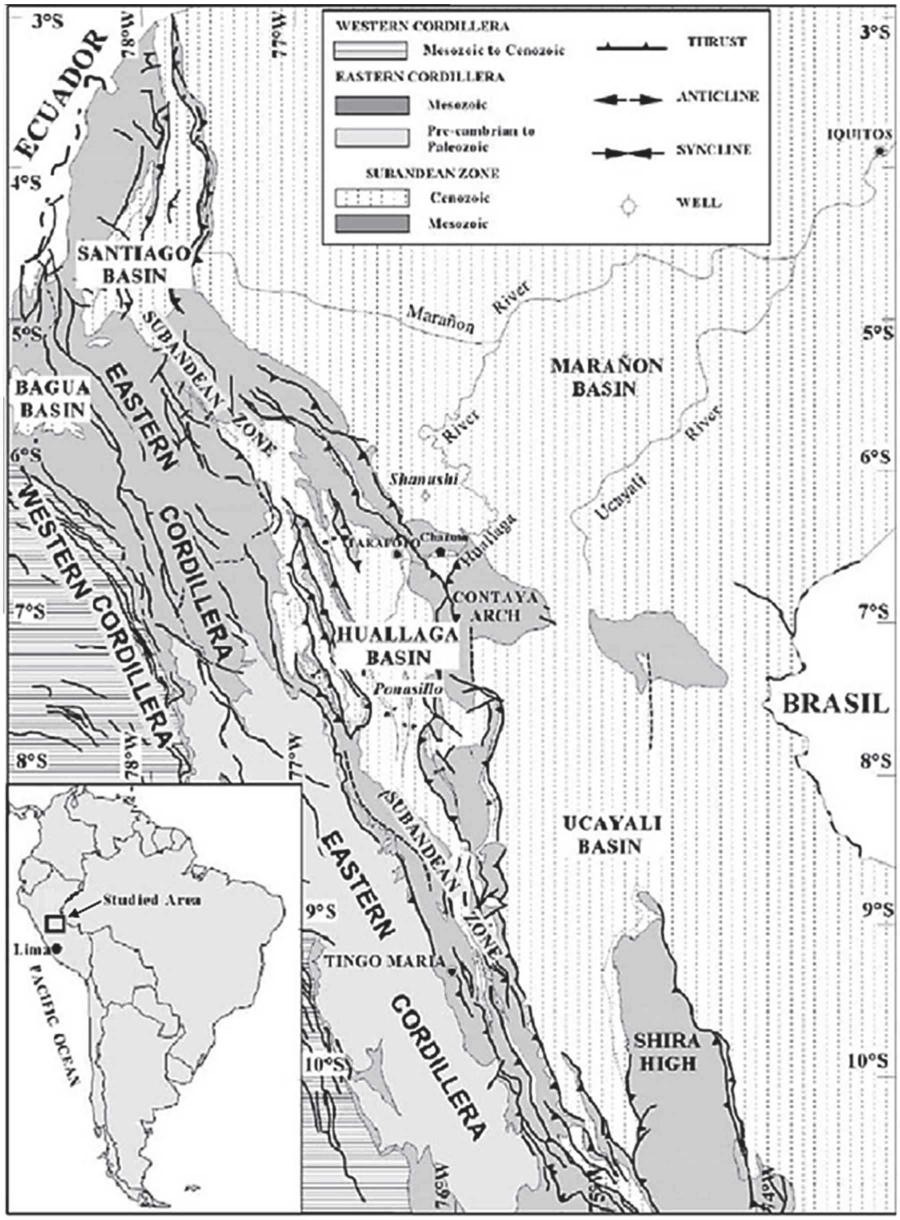

Figure 2. Index map of basins and uplifts in the region [1]

Cenozoic volcanism and block faulting are widespread in the study area. The dominant physiographic features are highstanding fault blocks composed of both sedimentary and volcanic rocks. Hermoza et al. [1] discusses the Cenozoic evolution of the Liata area, and describe the Cenozoic volcanic geology of this district and present a model for the Cenozoic evolution of the Maranion Rift.

Although the Cenozoic deformation of the study region is very pronounced, it is probably masking older structural trends of equal importance. Hermoza et al. [1] use the Quaternary fault trends, recent volcanism, high heat flow, and deep basin development as primary criteria for defining the southern portion of the Maranion rift. Using these criteria, the southeastern Cordilleras may define the southern limit of the rift. Their analysis of the shallow features which delineate the rift indicate a district deflection from north trending to northwest trending in the southern Maranion Basin. This deflection lies on trend with the older Burro-Florida structures and leads one to question how extensively Cenozoic deformation has altered older structures and how extensively older structures have guided Cenozoic deformation.

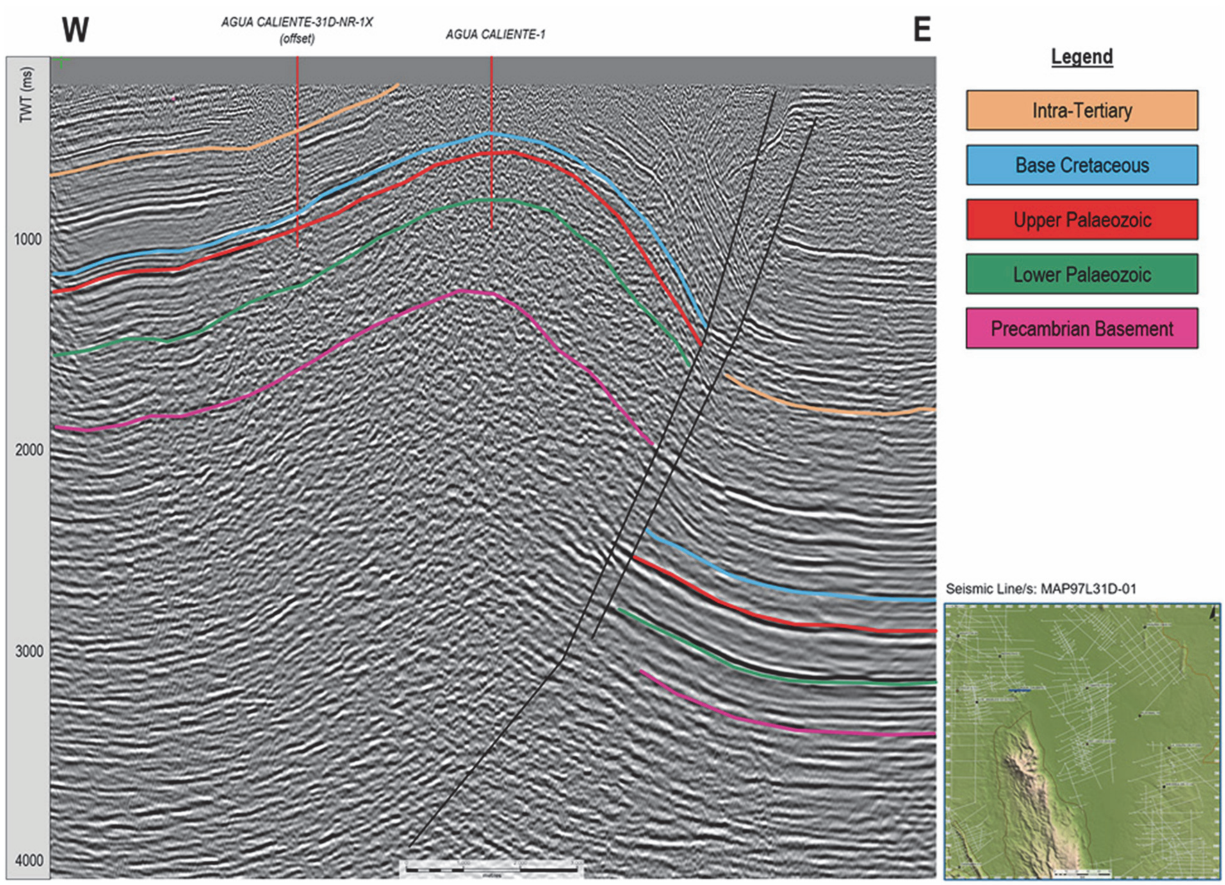

Figure 3. West-east section across the Agua Caliente structure showing the deep structure and the untested sub-thrust play (see foldout) [8]

2. Gravity data and interpretation

In order to provide reference gravity values, we utilized Japanese and Peruvian survey data collected between 1980 and 1998 [9; 10], and conducted more surveys in various parts of Peru in the 2020. Using these references, the gravity values were calculated dataset and Bouguer corrections were applied. Finally, a Bouguer anomaly map of Peru and in the studied areas was produced based on these data.

The gravity data of Figures 4, 5 represents complete Bouguer anomaly values computed for a sea level datum and reduction density of 2.67 gm/cc. These data were compiled from several sources [8; 9], and have been adjusted to the IGSN/71 base station network [11; 12]. Terrain corrections were computed using the computer programs of GravModel 1.1.5 [13] and should provide a significant improvement over previous maps [13]. The contours were drawn from grid values (2 km grid spacing) that were generated by the minimum curvature technique [5] as programmed by Surfer 8.

The data are somewhat sparse in northern Huanuco and the contours in that area show less detail than other portions of the map. However, in spite of this, a dominant northwest trend of anomalies is evident in southwest Liata and northern Huanuco. This northwest trend is generally parallel to the trend of the overthrust belt [1], and the Shira uplift, and the margin of the Ucayali Basin [1]. This northwest trend is also evident southeast of Huanuco where the strong north-south trend of the Shira is abruptly bent to the southeast. The dominance of this trend is surprising in light of the north-south trend of Basin and Range/Maranion rift structures in the area. Subanden Lineament [1] extends along roughly this same northwest trend. Pfiffner O. Adrian [3] noticed that a series of uplifts (the Deming Axis) also occur along this trend. This lineament is actuality several tens of kilometers wide and its origin is poorly understood. However, it seems to have served as a locus of deformation across eastern Cordillera, and western Cordillera from the Triassic to the present [10]. Thus, this northwest trend probably is a result of the combined effects of a Paleozoic tectonic zone, the margin of a Mezozoic basin, the overthrust belt, and locally normal faulting. The structural interrelations between these features are complex but their correlations must be more than coincidence. Presently, it is not possible to separate the gravitational signatures of these features. However, efforts to separate these signatures via digital filtering are progress.

Several other relationships between structural features and gravity anomalies are worthy of note because of their possible significance. Outcrops of Mezozoic rocks in the Subanden zone in southeast Huanuco also form a northwest trend. Gravity highs are associated with these outcrops and the apparent lack of an anomaly associated with the Big Mountains is probably due to the absence of any gravity stations in these mountains. This hole in the data coverage is a result of the problems with access and inadequate topographic mapping in this very remote area. Comparison of the western portion of the map (Figure 4) with the physiographic features (Figure 1) shows that topographic basins are marked by gravity lows and mountain ranges generally coincide with gravity highs. The Maranion Valley and Huallaga Valley are especially well defined by their gravity signature.

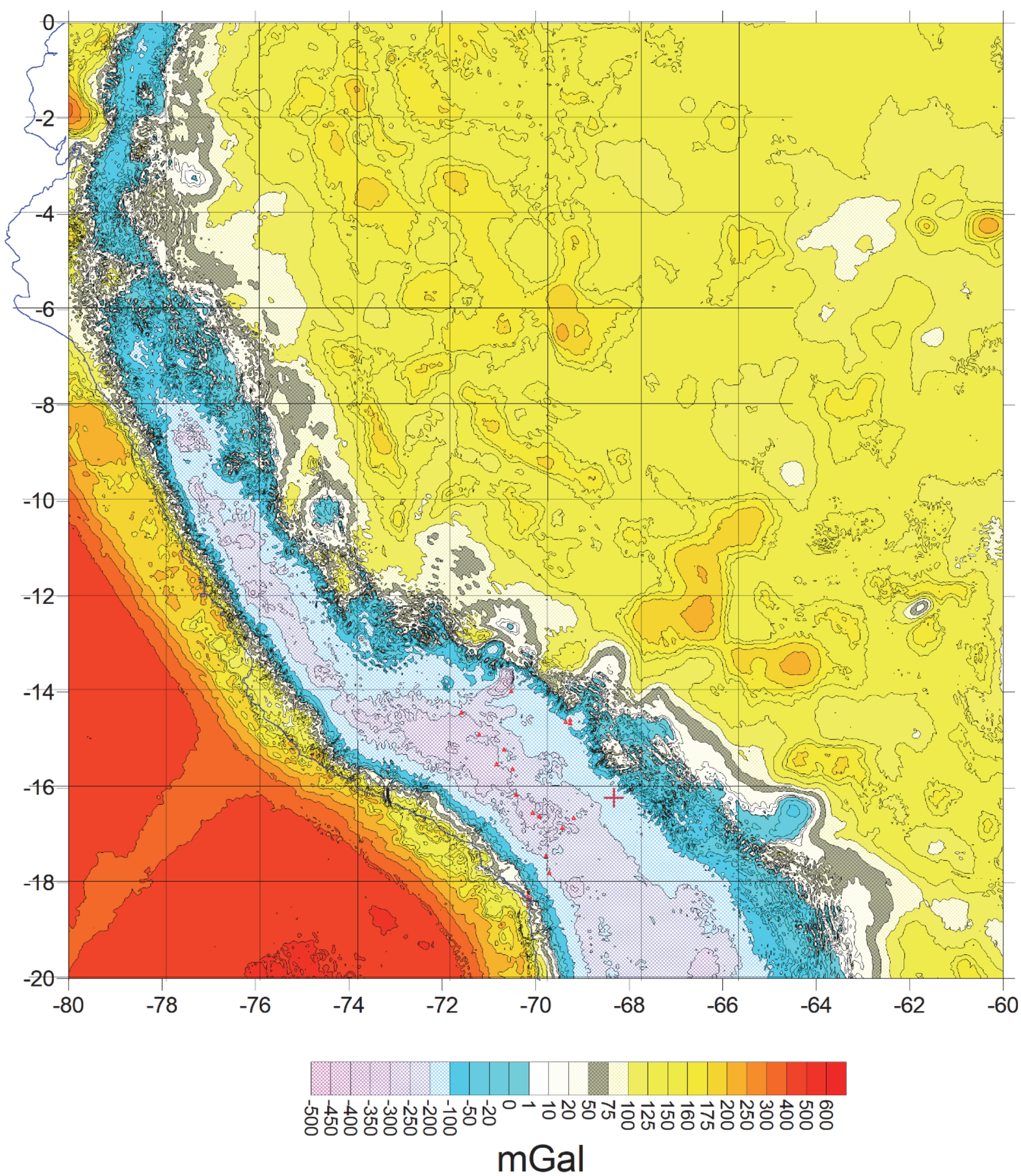

Figure 4. Complete Bouguer gravity map of Peru

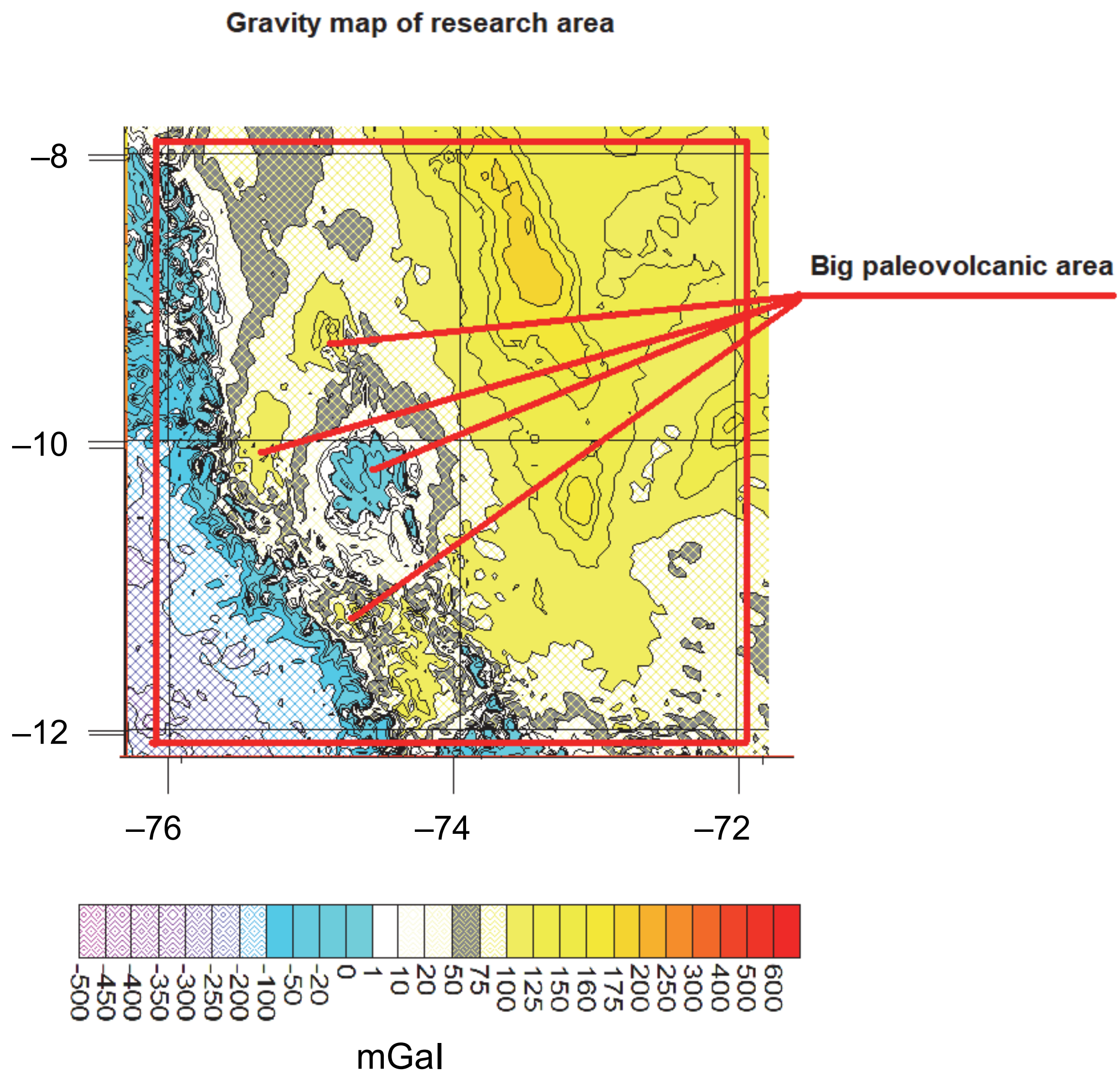

Figure 5. Complete Bouguer gravity map of the study area

The paleovolcanic fields in north Huanuco generally coincides with a gravity high. Directly northeast of the Lliata the surface geology would not predict the series of north-trending lows and highs seen on the gravity map. These anomalies suggest a complicated block-faulted subsurface structure in this area.

The Huallaga basin and Contaya arch trends north-northwest and coincides with several strong gravity lows. The faulting and subsurface structure of this area has received various interpretations and the pattern of gravity lows suggests that the structure is more complicated than of a single downfaulted block. There is a strong gravity high associated with the Eastern Cordillera. Southeast of Lliata, this high ceases to follow the topographic trend of the mountains.

The north-south trends north of Union have been associated with the Contaya Arch rift. However, the southeast bend near Union and Lliata mentioned above represents an example of the overlapping of structures in the subsurface [1]. The intense gravity low associated with this portion of the bolson may be due to both Cenozoic fill and the overthrust belt. In fact, pre-thrust, normal faulting may also be present in the area [1].

3. Magnetic data and interpretation

In order to provide reference magnetic values, we utilized Peruvian survey data collected between 1980 and 1998 [9; 10], and conducted more surveys in various parts of Peru in the 2020. Using these references, the magnetic values were calculated dataset and variation corrections were applied. Finally, a magnetic anomaly map of Peru and in the studied areas was produced based on these data.

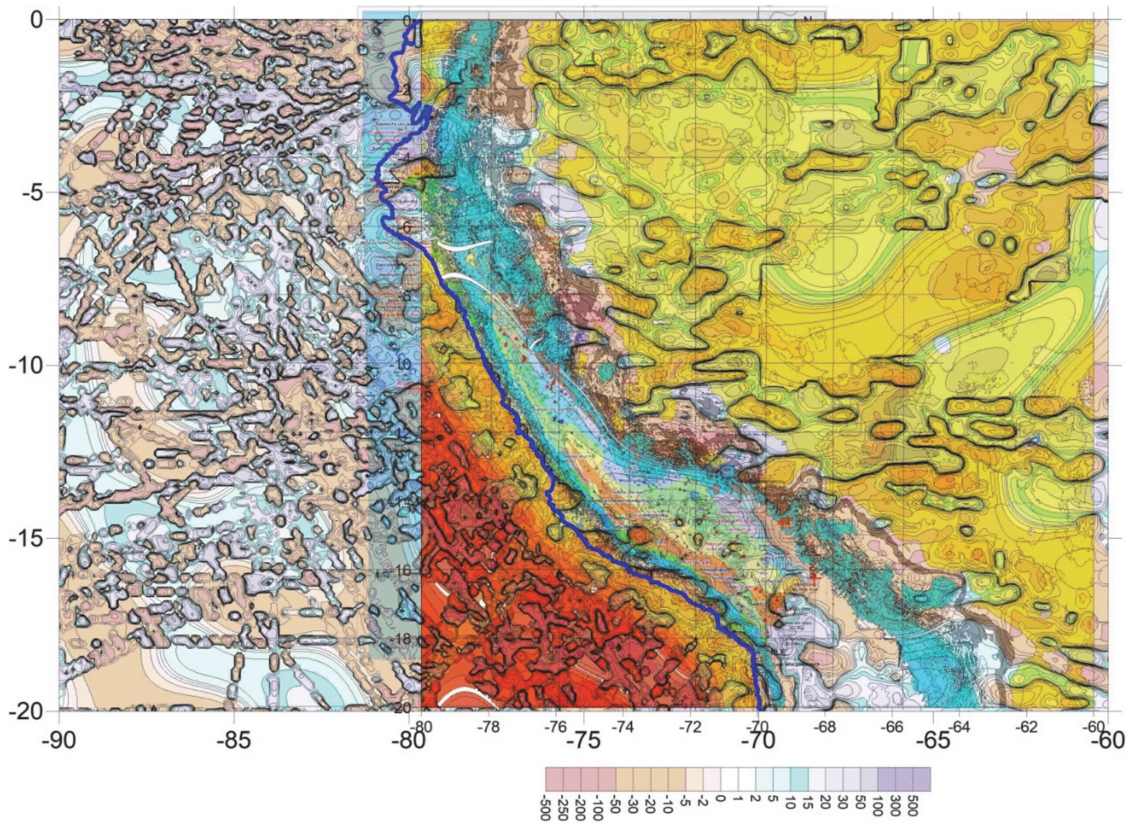

Figure 6. Map of magnetic anomalies of Peru

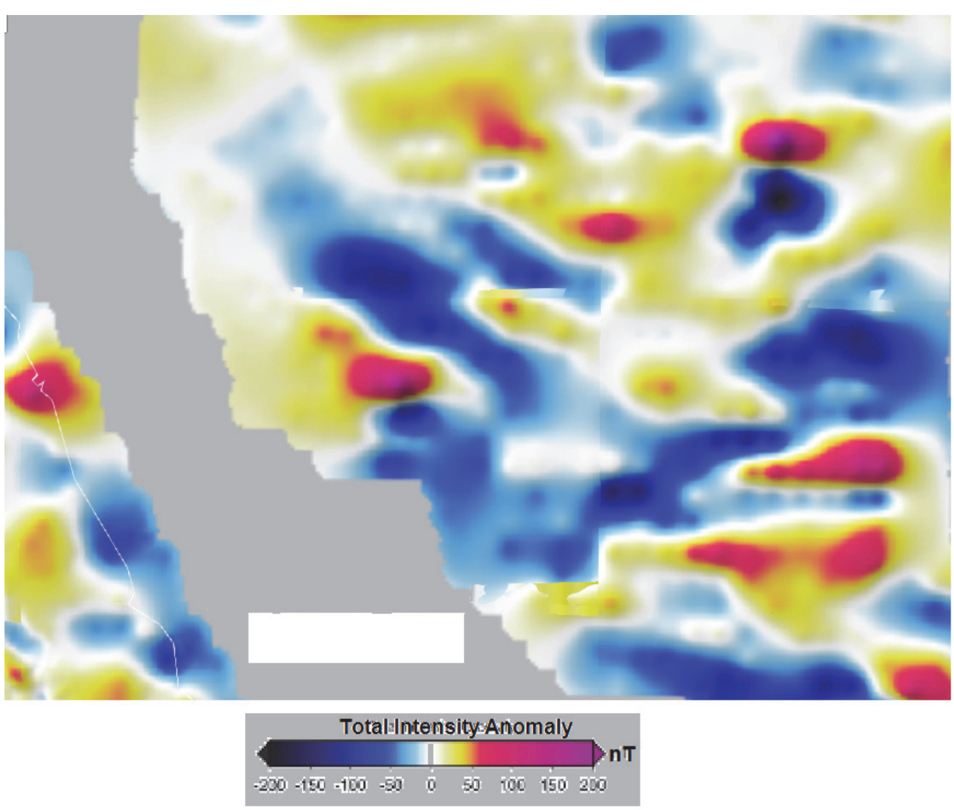

Figure 7. Map of magnetic anomalies of Huanuco (Peru)

The magnetic data of Figures 6 and 7, represents complete magnetic anomaly values computed for a sea level datum and total magnetic pole of 35 000 nT. These data were compiled from several sources Geological Survey of Peru) and have been adjusted to the IGRF-13 base station network [2; 14]. Terrain corrections were computed using the computer programs of MagModel 1.1.3v [13; 15–17] and should provide a significant improvement over previous maps. The normal magnetic field of the earth at the work sites was calculated using the IZMIRAN calculator. The contours [3] as programmed by Surfer 8.

Conclusion

The gravity and magnetic maps present here (Figures 4–6) defines the regional structural grain of the study area and delineates many local subsurface features. A northwest trend is clearly dominant and is probably the result of the superposition of several features. The overthrust belt is one of these features but existing geologic control and geophysical data are too sparse for a detailed interpretation. In addition to seismic reflection profiling, detailed gravity profiles could delineate some of the structural details of the thrusting with the aid of good geologic control. The extent to which the Maranion Fold-Thrust Belt Lineament, basement structures, and pre-existing basin margins affect the location of the overthrust belt seems to be a key question which further analysis of these gravity data may partially answer.

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